

## EL-GY 6123 Image and Video Processing, Fall 2017

### Programming Assignment 1 (Due 2/6/2017)

- 1) Implement 2D convolution using Python. Complete the following tasks:
  - a) Write a 2D convolution function. The inputs of this function should be an image array and a filter array, and the output should be the convolved image. Your output image should have a size equal to the complete filtered image (similar to the “full” option of MATLAB conv2 function). For simplicity, you can assume the filter has an odd length in both horizontal and vertical dimensions and has an origin at the center. Also you can assume pixel values are zero outside the original input image.
  - b) Write a main function, which will read in an image and allow a user to specify the filter size and filter coefficients. It will then call the convolution function from part 1) to filter the image. The program will show the original image and the filtered image and save the filtered image into a file after properly normalizing the pixel value range to 0 to 255. The program will also calculate and display the magnitude of Fourier transform of the original and filtered image, as well as frequency response of the filter. (In Python, you can use `scipy.signal.freqz()`)
  - c) Using your main program to filter an image with the following three filters:

$$H_1 = \frac{1}{16} \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix} \quad H_2 = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}; \quad H_3 = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

In your report, for each filter, you should discuss the difference between the original and filtered image, both in the spatial and frequency domain and explain how does the filtering effect correlate with the filter and its frequency response.

- 2) Image noise removal using averaging and Gaussian filters.
  - a) Create a noisy image, by adding zero mean Gaussian random noise to your image (In Python, the noise can be generated by using “`np.random.normal(mean,sigma,(img.shape))`”).
  - b) Apply your previous program to filter the noise-added image using an average filter of size  $n \times n$ , where  $n=\text{odd}$
  - c) Apply your previous program to filter the noise-added image using a Gaussian filter of size  $n \times n$  (Recall that with Gaussian filter, the filter size and the Gaussian filter parameter  $\sigma$  should satisfy  $n \geq 5\sigma$ )Try two different noise levels (0.01 and 0.1) and for each noise level different filter sizes (ex: 5x5 to 9x9 in step size of 2).

Your report should show the original, noise-added, and filtered images for each combination of noise level and filter size. Comment on for each noise level, which filter size is best for each filter and how does the two filters compare in their noise removal capability.